SPECIFICATION

Title of the Invention :

MODEM APPARATUS, COMMUNICATION APPARATUS AND COMMUNICATION CONTROL METHOD

Inventor(s) :

Nobuhiko NOMA
Mikio MIZUTANI
Toshiyuki OUGI

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MODEM APPARATUS, COMMUNICATION APPARATUS AND COMMUNICATION CONTROL METHOD

BACKGROUND OF THE INVENTION

Field of the Invention

The present invention relates to a modem apparatus using an xDSL technology that allows high-speed communications of several M bits/sec even with a telephone copper wire cable, and more particularly, to a modem apparatus, communication apparatus and communication control method that detect a CP (Cyclic Prefix) signal added to every data unit (a predetermined number of samples) of initializing signals.

Description of the Related Art

Against a background of the widespread proliferation of the Internet, there is a growing demand for high-speed access channels available for constant connection of the Internet. Furthermore, optical fibers are increasingly introducing forbackbone of carriers and use of ultra high-speed channels of giga-bit class is beginning in their core sections. On the other hand, most of subscriber channels connecting user residences and a carrier station are copper wire cables installed for telephones. Therefore, the introduction of an xDSL technology, which allows high-speed communications of several M bits/sec with telephone

copper wire cables, is under study.

One of the xDSL technologies is an ADSL system. The ADSL system uses carrier frequencies in a band of 35 kHz or higher, which is by far higher than the band used for telephones (4 kHz or below). For this reason, the ADSL system has an advantage of using telephone lines to carry out high-speed data communications without impairment of the telephone functions.

A voice modem using a band of 4 kHz or below sends a training signal prior to data transmission and then sends a data signal. An ADSL modem sends an initializing signal, which is equivalent to the training signal, and then sends a data signal.

FIG.7 shows a sequence diagram of an initializing signal sent by the ADSL modem. As shown in FIG.7, the initializing signal has a CP signal added at the beginning of every data unit (256 samples in the case of G.Lite) starting at some midpoint of the signal. The CP signal is configured by the same data as that of a predetermined number of samples (16 samples in the case of G.Lite) of the rear end of the data unit. That is, the 16 samples of the rear end of the data unit are copied and added at the beginning of the data unit, forming a unit of 272 samples (256+16) as a whole. Adding this CP signal at the beginning of every data unit also when a data signal is sent will prevent inter-code interference between data units. This also makes it possible to precisely demodulate a DMT (Discrete Multi Tone)

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modulated signal adopted by the ADSL system.

However, regardless of high-speed communication based on the ADSL system, the reception terminal cannot determine from which part of the initializing signal a cyclic insertion of the CP signal starts. For this reason, it is difficult to directly recognize the boundary between the CP signal and signal body. Here, the cyclic insertion refers to adding the rear 16 samples of the data unit at the beginning of the relevant data unit and repeating this procedure for every data unit.

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SUMMARY OF THE INVENTION

It is an object of the present invention to provide a modem apparatus, communication apparatus and communication control method capable of accurately detecting a CP signal sent at some midpoint of an initializing signal without any detection error and precisely demodulating a DMT-modulated signal.

The present invention calculates a product of present sampling data by sampling data, one data unit ahead, and retroactively adds up product values calculated for every sampling by going back to the time point 1 data unit ahead. The present invention then detects a reference timing with regard to a CP signal using the addition value.

BRIEF DESCRIPTION OF THE DRAWINGS

The above and other objects and features of the invention will appear more fully hereinafter from a consideration of the following description taken in connection with the accompanying drawing wherein one example is illustrated by way of example, in which;

FIG.1 is a functional block diagram of a reception system of a modem apparatus according to an embodiment of the present invention;

FIG.2 illustrates a connection mode according to an ADSL system;

FIG.3 illustrates an initialization sequence based on G.992.2;

FIG.4 illustrates an extract of a portion of an initialization signal including parts before and after a segue signal;

FIG.5 illustrates a relationship between a data pattern of a reverb signal and segue signal and adder output;

FIG.6 is a flow chart to detect a reference timing of CP detection in the modem apparatus according to the embodiment above; and

FIG.7 is a data sequence diagram of an initializing signal.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS

With reference now to the attached drawings, an

embodiment of the present invention will be explained in detail below.

FIG.1 is a functional block diagram of a reception system of a modem apparatus according to an embodiment of the present invention and is an excerpt of the part that detects a reference timing to ascertain the position of a CP signal in an initializing signal. Before explaining the configuration of the part corresponding to reference timing detection to ascertain the CP position, an example of the channel connection mode constructed via this modem apparatus will be briefly explained with reference to FIG.2.

A telephone station serving as a carrier station and a subscriber residence, a user residence, are connected via copper wire cable 21. At the subscriber residence, telephone set 23 and ADSL terminal side apparatus 24 are connected via splitter 22. Furthermore, personal computer 26 as a communication terminal apparatus is connected to ADSL terminal side apparatus 24 via a local network such as 10-BASE-T. At the telephone station, exchange 28 and hub (or router) 29 are connected via ADSL station side apparatus 27.

When communication terminal apparatus 26 carries out a data communication, an initializing signal is sent/received between ADSL terminal side apparatus 24 and ADSL station side apparatus 27 at the telephone station. This embodiment will be explained assuming that this modem apparatus is mounted on ADSL terminal

side apparatus 24 at the subscriber residence, but the modem apparatus can also be mounted on ADSL station side apparatus 27. Splitter 22 can be incorporated in ADSL terminal side apparatus 24 and no splitter is required in the case of G.Lite.

In FIG.1, AD converter 11 samples a reception signal sent via copper wire cable 21 and outputs the sampling data to auto gain controller 12. The sample data with gain adjusted by auto gain controller 12 is input to first shift register 13 and multiplier 14 in parallel.

First shift register 13 has a register length equivalent to the number of samples of 1 data unit. That is, in the case of G.Lite, first shift register 13 is configured by 256 delay elements. When certain sample data is input, first shift register 13 outputs the sample data 256 samples ahead to multiplier 14. Therefore, multiplier 14 calculates a product of the sample data input this time by the sample data 1 data unit ahead (256 samples ahead in the case of G.Lite). The product value output from multiplier 14 is assigned a polarity and input to second shift register 15.

Second shift register 15 has the same register length as that of first shift register 13 and has a structure having a tap to extract stored data from each delay element. Therefore, products of 256 samples from the present sample to the one 256 samples ahead by 256 samples from this sample to the sample 256 samples ahead with polarities assigned respectively are output in

parallel to second shift register 15.

Adder 16 adds up the 256 product values with polarities stored in second shift register 15. This addition value is input to minimum value determination circuit 17. Minimum value determination circuit 17 detects the position at which the time series data string made up of the addition values output from adder 16 reaches a minimum value as a reference timing and outputs a minimum value detected signal. As will be described later, the minimum value detected signal will indicate the position of the boundary between a first symbol and second symbol of the segue signal and the position 9 symbols later from there (256 samples×9) is the position of the beginning of the CP signal.

Here, an algorithm for detecting a reference timing used to ascertain the CP position from an initializing signal will be explained.

FIG.3 illustrates an initialization sequence according to G.Lite (G.992.2). The ADSL station side apparatus installed at the station sends 10 symbols of segue signal (C-SEQUE1) after sending 1024 symbols of reverb signal (C-REVERB3) in the initialization sequence. Furthermore, after sending 10 symbols of segue signal (C-SEQUE1), addition of a CP signal is started from the immediately following transmission signal. In the same way, the ADSL terminal side apparatus installed at the subscriber residence sends 1024 to 1056 symbols of reverb signal (R-REVERB2) and then sends 10 symbols of segue

signal (R-SEGUE1) in the initialization sequence. Furthermore, after sending 10 symbols of segue signal (R-SEGUE1), addition of a CP signal is started from the immediately following transmission signal.

FIG.4 shows the initialization sequence of the ADSL station side apparatus and shows symbol series of a section where a reverb signal (C-REVERB3) is changed to a segue signal (C-SEGUE1) and a section where a segue signal (C-SEGUE1) is changed to the following transmission signal.

In the case of G.Lite (G.992.2), 1 data unit (signal body) corresponding to 1 symbol of both the reverb signal and segue signal is configured by 256 data items. The reverb signal (C-REVERB3) repeats 256 data patterns for 1024 symbols and the segue signal (C-SEGUE1) repeats 256 data patterns for 10 symbols.

The reverb signal is the following signal defined in ITU-T G.992.2 or G.992.1. As a data string that forms a data stream corresponding to 1 symbol, the following pseudo-random sequence is generated.

In the case of upstream:

dn = 1 for n = 1 to 6

dn = dn-5 EXOR dn-6 (modulo2) for n = 7 onward

In the case of downstream:

dn = 1 for n = 1 to 9

dn = dn-4 EXOR dn-9 (modulo2) for n = 10 onward

The above sequence is divided every 2 bits and allocated on a complex plane expressed by X and Y axes

as follows. The "EXOR" above denotes an exclusive OR.

00 → X+ Y+

01 → X+ Y-

11 → X- Y-

10 → X- Y+

Suppose a sequence of 128 or 256 complex numbers allocated on the complex plane is:

Z1Z2 ······ Zm

where the first of the complex sequence is 00 and the portion called a "pilot tone" is (X+ Y+).

Furthermore, an inverse Fourier transform is applied to a sequence that links the above complex sequence with a complex sequence that constitutes Hermitian symmetry with respect to the relevant complex sequence:

Z1Z2 ······ Zm Conjugate of Zm ······ conjugate of conjugate Z1 of Z2

The 256 real number components of this inverse Fourier transform result constitute a reverb signal.

The segue signal is formed as follows: The above reverb signal is rotated 180 degrees on the complex plane except 00 on the complex plane and the position X+ Y+ called a "pilot tone" and the following complex sequence is obtained:

Z1Z2 ······ Zm

Hermitian symmetry with this is taken as follows:

Z1Z2 ······ Zm Conjugate of Zm ······ conjugate of conjugate Z1 of Z2

And this is subjected to an inverse Fourier transform. The 256 real number components of this inverse Fourier transform result constitute a segue signal.

The reverb signal and segue signal generated according to the above rule are signals with phases mutually inverted by virtually 180 degrees. FIG.5 shows that the reverb signal and segue signal have phases mutually inverted by virtually 180 degrees. The curve described in correspondence in time with the reverb signal and segue signal in FIG.5 represents addition values with polarities output from adder 16 at different sample time points. As shown in FIG.5, the phases of the last symbol (1024th symbol) of the reverb signal and the first symbol (1st symbol) of the segue signal are opposite over 1 entire symbol. For this reason, at the reception terminal, individual sample data items forming the first symbol of the segue signal and the sample data (individual sample data items forming a reverb signal) 1 data unit (256 samples) ahead from each sample time point have opposite polarities. Therefore, the product of the present sample data by the sample data 1 data unit ahead in the above positional relationship always shows a negative polarity. In the period of each sample data item during which the present sample data forms the 1st symbol of the segue signal, each product value has a negative polarity. Therefore, adding product values corresponding to the past 1 data unit (256

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samples) to the individual sample data items that form the 1st symbol of the segue signal shows a minimum value as shown in FIG.5.

This embodiment detects a minimum value from the time series data of addition values output from adder 16. As shown in FIG.4 and FIG.5, since the position at which the above minimum value is detected is 9 symbols (256×9) after the position of the beginning of the CP signal, once the position of the minimum value above is detected, the position at which the CP signal starts can be identified using that position as a reference timing.

FIG.1 shows the hardware circuit to detect a reference timing with regard to the CP signal in the modem apparatus above, but it is possible to execute the processing from AD converter 11 onward by software. FIG.6 is a flow chart to execute CP detection processing in the modem apparatus above.

At a sampling time (S61), 1 sample is input (S62) and a product of the sample data this time by sample data 1 data unit ahead is calculated with a polarity (S63). Then, product values for 256 samples corresponding to the past 1 data unit with polarities are added (S64). Then, it is determined whether the addition value this time is a minimum value or not (S65). An algorithm for determining a minimum value is not particularly limited.

The sampling number at the position at which the minimum value is detected in step S65 is recorded (S66) and the CP signal position is identified from the

recorded sampling number (S67). After the CP signal position is identified, the data unit of the data signal sent after the initializing signal is extracted and demodulated with reference to the CP signal added at the beginning of the data unit.

In the connection mode shown in FIG.2, ADSL terminal side apparatus 24 is connected to communication terminal apparatus 26 via local network 25, but it is also possible to use a mode in which communication terminal apparatus 26 incorporates ADSL terminal side apparatus 24. Furthermore, communication terminal apparatus 26 is not limited to a personal computer, but can be any other apparatus equipped with a facsimile apparatus (including Internet fax) and a communication function.

The present invention described above can provide a modem apparatus, communication apparatus and communication control method capable of accurately detecting a CP signal sent at some midpoint of the initializing signal without any detection error and precisely demodulating a DMT-modulated signal.

The present invention is not limited to the above-described embodiments, and various variations and modifications may be possible without departing from the scope of the present invention.

This application is based on the Japanese Patent Application 2000-094257 filed on March 30, 2000, entire content of which is expressly incorporated by reference herein.